LIVERPOOL

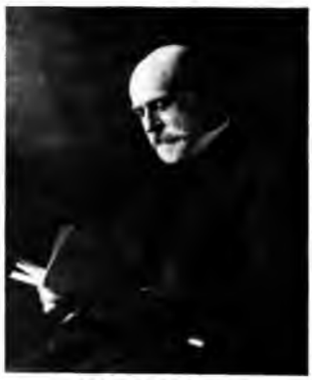
GEOLOGICAL ASSOCIATION.

JOURNAL.

VOLUME XIV.

SESSION 1893-94.

LIVERPOOL:
J. DONALD, PRINTER, 495, PRESCOT ROAD, OLD SWAN.
1894.



View of the South Entrance to Storeton Quarry.

* Footprint Bed.

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The Authors only are responsible for the statements and opinions expressed in their respective Papers.

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T. Mellard Read, C.E., F.G.S.

Paper— " Genesis of Mountain Ranges."

Do. " High Level shelly sands and gravels."

Do. " A cooling and shrinking globe and the origin of Mountain Ranges."

Do. " Continental growth and Geological periods."

T. MacKenny Hughes, M.A., F.S.A., F.G.S.

Pamphlet—" Notes on the Geology of the Vale of Clwyd."

Do. " Caves and Cave Deposits."

Do. " The Ffynon Beuno Caves."

Do. " The Drifts of the Vale of Clwyd and their Relations to Caves and Cave Deposits."

Do. " On Caves."

Do. " On the Cae Gwyn Cave."

J. Herrert Jones.

Set of Photographs illustrative of Devonshire Scenery and Tin Mining.

1893-94.

Copies of the *Journal* of the Association, Vol. XIV., 1893-4, have been sent to the following Institutions and Societies, and exchanges received from those marked with a *.

GREAT BRITAIN AND IRELAND.

*Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
Burnley Literary and Philosophical Society.
*Cardiff Naturalists' Society.
*Chester Society of Natural Science and Literature.
*Cornwall Royal Geological Society, Penzance.
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Department of Mines, Melbourne, Victoria.
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*Nova Scotian Institute of Natural Science, Halifax.
*Geological Survey, Washington (D.C.), U.S.A.
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Wagner Free Institute of Science, Philadelphia.
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State Mining Bureau, Sacramento, Cal., U.S.A.

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Liverpool Geological Association.

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Moore, W. R. Fitzgerald, C.E., M.E.	Consul of Chili, Collins Street, Melbourne.
Morris, John, J.P.	4, The Elms.

L. Le Feuvre; Italian Marbles, collection of Terebratulidæ and Rhynchonellidæ, section of the boring at Point of Ayre showing the discovery of Salt at a depth of 600 feet, by the President, who also exhibited specimens of Eozoon just received from Sir J. W. Dawson, along with rock specimens and slides of the same which have been mistaken for Eozoon; Eocene Fossils from Isle of Wight, by Mr. A. Dudley; New Zealand Minerals, by Mr. J. Paterson; Australian Minerals, by Mr. R. T. Litton, F.G.S.; Model of Stanley Brickfield, by Mr. J. Thompson; Fossil Gasteropod, by Mr. C. Potter; Fossil Plants from Doulton's Delph, by Mr. T. R. Connell.

On the meeting being called to order a number of exhibitors explained their exhibits, which led to a lively and interesting discussion.

ORDINARY MEETING,

Held at the Free Library on Monday, February 5th, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

A paper, by Mr. Cecil F. Webb, D.D.S., entitled "THE BEGINNING OF PHYSICAL LIFE," was read by Mr. Paterson in the unavoidable absence of the writer.

A FIELD MEETING was held at Poulton on Saturday, March 3rd, 1894, conducted by the President. The new railway cutting there is in the Keuper sandstone, which is overlaid by glacial deposits. Attention was also directed to the glacial striæ and to the slickensides seen in the adjoining quarry.

ORDINARY MEETING,

Held at the Free Library on Monday, March 5th, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

EXHIBITS.—Mr. T. R. Connell exhibited several erratics collected at Poulton at the Field Meeting on the previous Saturday, and Mr. Howarth showed photographs of the contorted beds at Wallasey.

Mr. Howarth then delivered an address on "COAL MINING," which was fully illustrated with photographs, drawings, sections, instruments, lamps, &c., &c.

A FIELD MEETING was held on Easter Monday, March 25th, 1894, at Llangollen, conducted by Mr. A. R. Pritchard. The special object of this meeting was to examine the zone of Phillipsia. Several specimens of the interesting Trilobite were found. Mr. Pritchard fully described the geological character of the district, showing the relation of the carboniferous limestone to the silurian rocks, pointing out also the various zones of the limestone.

ORDINARY MEETING,

Held at the Free Library on Monday, April 2nd, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

EXHIBITS.—Mr. White exhibited several good specimens of Cotham or landscape marble, asking information about the character and origin of the dendritic markings.

An address on "GEOLOGY IN ITS RELATION TO SCENERY" was given by Mr. W. H. Read, lavishly illustrated with lantern views.

ORDINARY MEETING,

Held in the Free Library on Monday, May 7th, 1894, Mr. T. R. Connell, Vice-President, in the Chair.

A paper was read on

"GRANITE: ITS PEDIGREE AND RELATIONS,"

By REV. OLIVER BICKERLEGGE,

which was copiously illustrated with rock specimens and micro slides.

A Field Meeting was held at Ingleton on Whit Monday, May 14th, 1894, on which occasion many illustrations of geological principles were studied, notably the erosion of limestone by running water.

A junction of the silurian and carboniferous limestone was observed in a recess behind a small cascade.

ORDINARY MEETING,

Held at the Free Library on Monday, June 4th, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

Exhibits.—A large series of slabs from Storeton, with footprints, were exhibited by Messrs. Jeffs and Beasley, to illustrate the paper of the evening. Mr. Potter exhibited a jug with artificial dendritic markings which he thought would illustrate the markings in cotham marble.

The following paper was then read:

"NOTES ON THE STORETON SERIES OF FOOTPRINTS,"

By Osmund W. Jeffs.

[Introduction.]

Every geological student is familiar with the name of Storeton Quarry, which may fitly be termed the "Home of the Cheirotherium," celebrated as being the scene of the earliest discovery in England of the fossil footprints, first described by Messrs. John Cunningham and James Yates in 1839.

Five years previously, similar impressions to those from Storeton had been found by Dr. Kaup at Hessburg, in Saxony; and earlier still, in 1828, were discovered the famous series of chelonian and reptilian markings in the Triassic strata of Corncockle Muir, Dumfriesshire. These ichnites were first described by the Rev. Dr. Duncan, and afterwards

in an elaborate Memoir by Sir William Jardine on "The Ichnology of Annandale," published in 1853.

Our specimens from Storeton have never yet received the same magnificent illustration bestowed upon those described in Sir William Jardine's Memoir; for, although they have been frequently referred to, and some of them figured in geological text books and other more popular works, no complete monograph has yet appeared on the subject of our local Triassic ichnites, and several forms of these saurian impressions have never yet been adequately described or even illustrated.

We, in Liverpool, are fortunate in having so close to us a quarry of such historical and palæontological interest. The neighbouring museums of Liverpool, Bootle, Chester and Warrington possess admirable examples of footprints from local sources for our study. The quarries at Storeton are by no means exhausted; and if, at the present time, these fossils are of comparatively rare occurrence, it is quite possible that new discoveries may yet be made there which will throw light on many points in their history now obscure.

Fifty years' study of these footprints has left their origin, so far as exact identification with any known animal is concerned, a matter of as much mystery as when Sir Richard Owen gave attention to the subject in his classical work on "Palæontology." All the evidence, in fact, which we have accumulated since that time has only brought us to a negative position, and taught us that the explanation first suggested by Owen and thereafter copied into nearly all our popular geological text books is not entirely correct.

On this occasion my purpose is simply to describe a series of ichnites from my own collection, illustrating some of the forms yielded by the Lower Keuper strata of Storeton, leaving for the future a more comprehensive account of our Triassic footprints and the animals which made them.

THE STORETON "FOOTPRINT BED."

The forms described have all been obtained from the "footprint bed" at the Storeton quarries (with the exception, named below, of two specimens from Oxton Heath). This "footprint bed" is a thin stratum of sandstone, with seams of white clay, together some three or four feet in thickness, which is exposed at several points along the quarry excavations, where it may be traced for some distance. [For a description of the structure of the Storeton quarries the reader is referred to the "Geology of the Country around Liverpool," by G. H. Morton, F.G.S. (2nd edition).] The view of the entrance to the South quarry (see plate) shows the position of the footprint bed on each side of the tramway cutting leading into the quarries.

Description of Specimens.*

Genus Cheirotherium.—I first refer to the well-known impressions to which the name of "Cheirotherium" was originally given by Dr. Kaup, under the idea that they were of mammalian character. In the event of their being afterwards proved to be saurian, the alternative name of "Chirosaurus" was proposed. The latter term, being the more correct—all the indications pointing to a reptilian origin of the footprints—has been adopted by the British Museum authorities (see "Catalogue of the Fossil Reptilia and Amphibia in the British Museum"), but it does not seem to have found its way into general geological literature or into our local museums. The type species of this genus is the *Cheirotherium (Chirosaurus) barthi*, from the Bunter of Hessburg. Other species are: *C. geinitzi* (from Karlshafen), *C. minus* (from Vogelsburg), and our local species, *Cheirotherium stortonense* (Morton)—or, to use its present official designation, *Chirosaurus stortonensis*. A much larger species found at Lymm (by Dr. Ricketts) and Tarporley (described by Sir P. Egerton) is known as *C. herculis*, measuring 15 inches in length.

* This part of the Paper was illustrated by the specimens described, which were placed on the table for inspection.

The following specimens are exhibited, all from Storeton:

1. (No. 130). Slab showing right-hand, hind and fore feet of *C. stortonensis*. Pentadactylate digits. Lengths of pes, 7½ in.; length of manus, 3 in. All the digits are perfect. The two feet are close together, being less than 1 in. apart. The toes are narrow and tapering, the first showing the characteristic turning inwards, like a thumb. In all the true Cheirotherian impressions the digits radiate from a centre like those in an outspread human hand. [Plate I., Fig. 1.]

2. (No. 132). Hind foot of *C. stortonensis*; length, 8 inches.

3. (No. 135). Ditto, large specimen; length, 10 inches; covered with impressions of a scaly skin.

4. (No. 136). Slab, showing portions of *C. stortonensis*. Length of pes., 6 in.; length of manus, 4 in.

5. (No. 137). Slab containing the natural mould of the impression of a medium-sized footprint; pes. about 8 in. in length. These moulds or hollows in which the animal impressed its foot into the sand are far more uncommon than might be imagined, and this is the only perfect specimen I have been able to obtain. Its preservation is evidently due to the sandy matrix. Most of the "moulds" occur in the soft clay which is intercalated in the footprint bed.

6. (No. 133). Slab, showing impressions of three digits only (middle digit 6 in. in length), similar in character to Cheirotherium, first digit wanting: fifth digit barely traceable by a mark in the sandstone. No cast.

7. (No. 134). *Genus non det.*—Slab, showing hind and fore feet of a smaller species, with narrow toes. Length of pes., 3 in.; length of manus, 1½ in. The toes in this species all curve inwards, and are not separated, nor do they radiate as in Cheirotherium.

General group of ichnites, illustrating the Triassic palæontology of Wirral:—

8. (*a*) (No. 138). Small footprint of *C. stortonensis* (imperfect), one digit missing. (Storeton).

9. (*b*) (No. 140). Ripple marked slab. Waterstones (from boulder clay, Caldy).

10. (*c*) (No. 141). Slab with suncracks. Waterstones, Irby.

11. (*d*) (No. 142). Slab showing rain pittings and a remarkable medial impression running in a straight line, which may be attributed to the track made by the point of a tail trailing on the ground.

Impressions of Lizard-like Saurians and Others.

Of impressions made by smaller species of reptilia, the Keuper, both at Storeton and Oxton, presents several examples. With the exception of *Rhyncosaurus* itself, very little is known of these creatures; for, although a great number of bones have been found in the Triassic strata, not only of Europe but of America and South Africa (Karoo beds), it is still a matter of difficulty to correlate the footprints with any known species of animals. Perhaps we know the most about *Rhyncosaurus articeps*, a lizard-like reptile possessing a bird-like skull, with a curved horny beak and a single row of minute acrodont teeth. It had a length of 3 feet, and from an excellent typical specimen from Grinshill, in the museum at Shrewsbury, we can form a fairly good reconstruction of the animal.

The difficulty in deciphering these small footprints is increased by the fact that several kinds of impressions are often found together on the same slab, in addition to the frequent superposition of one impression upon another, as the animals walked across the expanse of sand in various directions.

Among the specimens exhibited are examples of five species, all of which are probably the prints of small reptiles.

12. *(a)* (Nos. 123, 124, 125). *Rhyncosaurus.*— Four well-defined digits, with occasional vestiges of a fifth digit, much shorter than the others, possessing short claws, *curved inwards.* There is sometimes the mark of a projecting spur at the back of the foot. [See Pl. II., fig. 3.] Length of foot, 1½ inches. The middle toe often extends beyond the others. It is difficult to distinguish between the fore and hind feet, and the impressions follow so closely that the successive tracks of the animals' march are not clearly defined. All the toes curve slightly in the same direction. [See Pl. II., fig. 4.] These impressions frequently occur on slabs exhibiting the tracks of Cheirotherium, often being superposed on the actual imprint of the larger saurian.

13. *(b)* (Nos. 127, 129.) *Genus non det.*—Tracks of a smaller animal, ¾ inch in length, with a more stubby foot, and very distinct claws on the digits; the first digit very short, often indicated by a mere point where the claw has penetrated the sand; four distinct toes, probably had a rudimentary fifth. The digits do not display the same parallelism as in the specimens attributed to Rhyncosaurus. [Plate III., figs. 5, 6].

14. *(c)* (No. 122.) *Genus non det.*—A minute form, ½ in. long, showing four digits, tapering to a point; no vestige of claws.

15. (*d*) (No. 121.) *Genus non det.*—Three rather broad digits, with claws (? webbed). Not well defined; may be same as (*b*).

16. (*e*) (No. 120.) *Genus non det.*—An oval impression, with concave terminated digits, four or five in number, and a hinder projecting spur (? Chelonian). Toes webbed. (Plate I., fig. 2).

17. Two slabs from Oxton Heath (found by Dr. Ricketts), covered with impressions of (*a*) *Rhyncosaurus*, and probably of those included under (*b*) *Genus non det.*

18. (No. 139). A large slab, formed *in situ* at the South quarry, Storeton, at Easter, 1894, by Mr. Norman Jeffs. Shows specimens of several varieties—the slender-toed Rhyncosaurus; the minute form (*c*), several tracks; the stubby form (*b*); and both the fore and hind foot of a similar species to 7 (specimen No. 134), resembling the Cheirotherium, but of smaller size, and differentiated from that species by having the digits all pointing in the same direction.*

THE BOOTLE MUSEUM COLLECTION.

The Museum at Bootle contains a fine collection of footprints from Storeton and other localities which are of historical interest, as they include some of the original slabs obtained for the old Natural History Society of Liverpool. They originally formed part of the collection at the Museum of the Royal Institution at Liverpool, from whence they were removed after their purchase by the Corporation of Bootle. Ten of the slabs are arranged in cases on the grand staircase leading to the Museum. One or two smaller specimens (including *C. herculis*) are to be seen in one of the lower rooms of the building, in the general geological collection. Of the large slabs, seven have been photographed by Mr. Anyon, of Bootle. The following is a list of the large slabs, for which I am indebted to the courtesy of Mr. J. J. Ogle, Hon. Curator, and to Mr. H. C. Beasley, who obtained particulars of these interesting specimens:—

Slab No. 3 exhibits a surface of sandstone covered with large suncracks and footprints of *Rhyncosaurus*. Length, about 2 ft. 6 in. (From Runcorn).

* The specimens described above do not exhaust the varied types found at Storeton; but I have confined my remarks to specimens in my own collection. My friend, Mr. H. C. Beasley, possesses some other types of a highly interesting character, which I trust will ere long be fully described by his able pen.

Slabs Nos. 4, 8 and 9 are presumably from Storeton, and contain impressions of *Rhyncosaurus*, &c., which have been figured by Mr. Morton. On No. 9 may be seen an almost illegible label to the effect that the impressions are those of "lizards and tortoises."

Slab No. 5, from Storeton (? Runcorn), showing footprints somewhat resembling the Cheirotherium, but smaller in size, and exhibiting a different mode of progression.

No. 6 is a specimen from Hessburg, Saxony, obtained some years ago in exchange for one from Cheshire. It is similar to that figured by Buckland in his "Bridgewater Treatise." It exhibits a consecutive series of Cheirotherian tracks over a surface covered with suncracks.

Slab No. 10, from Storeton. Originally figured by the Liverpool Natural History Society. It was presented by Mr. Tompkinson to the Royal Institution. It shows a consecutive series of tracks of the Cheirotherium, exhibiting in a marked degree the difference in size between the fore and hind feet. Impressions of a smaller animal are also seen on this slab.

An interesting feature of two of these slabs is noticed by Mr. Beasley in his Presidential Address to the Liverpool Geological Society in 1889. They show certain impressions of the armoured integument of the animal, as if it had "squatted down on its haunches." "One slab," continues Mr. Beasley, "shews distinctly parts of a limb."

Note on the Labyrinthodonts.

The larger footprints known as belonging to the Cheirotherium, have long been attributed, on the authority of Sir R. Owen, to one or other genera of Labyrinthodonts, an order of animals now quite extinct, belonging to the Class *Amphibia*.

The progress of geological science shows many examples of the evils of hasty generalisation from imperfect data, and

it would seem that the supposed identity of our Storeton footprints with *Mastodonsaurus* or some other Labyrinthodont is a case in point.

In an able paper contributed to the Transactions of the Liverpool Geological Association in 1889 by Mr. James Hornell, the author records an interesting series of investigations on Labyrinthodonts, chiefly from a biological point of view, and though he apparently accepts Owen's correlation—since he terms it "successful" (op. cit., p. 67)—he shows very clearly that the Cheirotherian impressions do not coincide with the *normal* type of Labyrinthodon. For the "hand footed kind, where the hind limbs by reason of their greatly increased size depart from the central type," Mr. Hornell proposes a separate classification in a sub-order. But it may be pertinently asked whether there exists any evidence from the skeletons of Labyrinthodonts, now so numerously discovered in the Coal Measures, Permian and Triassic strata, of this special type of Labyrinthodon?

It will be recollected that the familiar idea of the Labyrinthodon is that exhibited in Mr. Waterhouse Hawkins' famous restorations at the Crystal Palace, Sydenham, which represent an animal corresponding in a realistic manner to Kingsley's description of "a short, squat brute, as big as a fat hog, with a head like a crocodile or huge frog; very large hands behind, short ones in front, waddling about on the sands, dragging his tail after him."

Since Owen correlated the Labyrinthodon with the Batrachia, a great mass of evidence has come to light, through the researches of Burmeister and Fritsch in Germany; Professors Huxley, Seeley and Miall in England; and Professors Cope and Marsh in America. It is now accepted that the Labyrinthodon was more akin to the salamander or newt than to the frog. Indeed, the skeletons which have been obtained entire from the petroleum shales of Germany show none of the supposed frog-like affinities. The Labyrinthodon

was in fact a primeval salamander, the species varying in size from small creatures, 8 ins. in length, to huge animals of eight or nine feet.

It is but fair to state that Owen recognised the footprints of Cheirotherium as resembling those of a salamander,* although he at the same time attributed them to a supposed batrachian. In his marvellous restoration of the Labyrinthodont, *Mastodonsaurus*, from Coton End, Warwick, Owen judged by the simple relics—chiefly of the teeth, parts of the skull, an ilium and humerus—he found there; but our present knowledge of the structure of these animals (which has been most minutely and elaborately investigated by a Committee of the British Association, reported upon by Professor Miall) is founded upon material which did not exist when Owen wrote his treatise in 1842. Even now our knowledge of the limbs of Triassic species of Labyrinthodonts is imperfect, and thus an important link in the chain of evidence required to enable us to correlate the footprints is wanting. Nor are we helped much by studying the limbs of the Carboniferous species of these amphibians; for, on the authority of Professor Miall, the corresponding parts of the fore and hind limbs of Labyrinthodonts are very similar in form, and present no uncommon difference of size. This feature, it is very evident, does not agree with the fossil footprints of Cheirotherium; and the more we study the known forms of true Labyrinthodonts (of which Miall, in 1874, described no fewer than thirty-one genera and a much larger number of species), we are driven to the conclusion that whatever was the mysterious animal by which the larger footprints at Storeton were made, it cannot be referred to any *known* species of Labyrinthodont.

Referring to Owens' hypothesis that the Triassic Labyrinthodonts had in some measure the habits of frogs, Professor Miall states: "The supposition will not stand a moment's

* " . . . in having the shorter toe of the hind foot projecting at a right angle to the line of the mid-toe." Miall considers this feature common to other orders of reptilia.

consideration. That a Labyrinthodon, with its greatly expanded and prolonged head, could have leaped a yard without severe shock is improbable." "If we interpret its extremities according to the Cheirotherian footprints," Professor Miall continues, "the Labyrinthodon would be a leaping animal of gigantic size, weighted with protective scutes, having little expanded toes, and not provided to our knowledge with a single one of those special provisions which enable large animals to leap great distances with safety."

From these considerations, so forcibly adduced by one of the most eminent biologists of the present day, there seems little escape from the conviction that the Labyrinthodonts were distinct from the animals by which the Cheirotherian footprints were impressed in our Keuper rocks. It is not a little remarkable that although the observations which, by your courtesy I have been permitted to bring under your notice, though in a necessarily brief and imperfect form, have been before the scientific world for so long, even in works on the subject issued so recently as the present year no hint is given as to their bearing on the question. It is further remarkable that the correlation of Owen, brilliant though it was, being based on what now appears to have been evidence of too scanty a nature, should continue to be quoted as if the subject were in no way disputed by modern authorities.

If our favourite Cheshire Cheirotherian footprints are not those of a Labyrinthodont, then to what animal do they belong? It has been suggested by Professor Miall that, while some of the footprints grouped together so heterogeneously may be Labyrinthodont, others are not improbably Dinosaurian. We know that the erstwhile equally mysterious trydactle footprints of the Connecticut valley, at first supposed to be impressions of birds, are now shown by the discovery of actual skeletons to be the prints of enormous dinosaurian reptiles. In the same Keuper quarry at Warwick

where Labyrinthodont teeth were found, remains of Dinosauria occur. If there are no characteristic Labyrinthodont features about our footprints, can it be said that they possess none of the attributes of Dinosaurs?

I venture to think that this problem is not one very hopeful of elucidation until we are in possession of a further series of bones of Triassic saurians, and especially of bones showing the structure of the limbs, which appear to be so unaccountably wanting in England. Our Keuper strata are not well adapted in their composition for the satisfactory preservation of fossils; but I trust that patient search may reward the labours of the energetic band of geologists who have exercised so much zeal in deciphering the complicated records of the rocks around us in our neighbourhood.

GRANITE AND ITS RELATIONS.

By Rev. O. Bickerlegge.

[*Read May 7th, 1894.*]

There are but few of Nature's phenomena that are not full of interest and food for thought to the earnest student. The simplest and most common object we meet with will often suggest to such an one the questions—Whence? When? Why? Questions easily propounded, but not always easily answered in a manner that may be deemed satisfactory.

Whether the world is full of interest or simply a blank will depend largely on what lies behind the eye of the observer. Whether the inner vision can pierce the material substance and see beneath and beyond it purpose, plan or reason, will depend largely on the measure of the trained intellectual and moral forces that are placed at the disposal of the organs of sense, with which man is so richly dowered

But my purpose is not to preach a sermon on stones, but rather to point out a few facts, and possibly fancies, along the lines of the title of my paper.

In studying granite we must remember that we are not dealing with a rock so much from a chemical or mineralogical point of view as from a mechanical one. It may be defined as a rock in which its constituents are found in a crystalline granular condition, without any paste, matrix or connecting medium. Thus its granular nature begets its name, granite. But although its name does not convey any very definite idea of its mineralogical or chemical nature, yet it has in its composition a certain recognised type.

Felspar, quartz and mica constitute what I would call a typical granite. At the same time, a rock may, I think, be considered a true granite although either of these may be wanting, or be replaced by another mineral; but I should say no rock, whatever its character, could be considered a granite if all three were absent.

In all books on Geology more than twenty or thirty years old granite is spoken of as the lowest and oldest of all rocks, and was supposed to be the foundation of the earth's solid crust. Such a view, however, is now abandoned. "It is known, indeed, that granite, so far from being in all cases an original rock, may be of almost any geological age. Some is undoubtedly as old as the Silurian period, while other granites are certainly as young as the Tertiary rocks, and perhaps of more recent date."—*Enc. Brit.* Many geologists regard granite to be a metamorphic, rather than as a truly igneous, rock. It has been pointed out that a passage may be traced from granite to gneiss, and that gneiss may be considered as an altered sedimentary rock. "That some granite is of a metamorphic origin—that is to say, has been produced by the gradual softening and recrystallization of the rocks at some depth within the crust of the earth, seems to be now satisfactorily established."

Fundamentally igneous and metamorphic granite seem to be due only to different modifications of the same subterranean process. A mass of originally sedimentary rocks may be depressed to a depth of several thousand feet within the earth's crust, subject there to vast pressure and considerable heat in presence of interstitial water or steam, and may thus be metamorphosed into crystalline schist. A portion of this mass undergoing extreme alteration may so completely lose all traces of its original fissile structure as to become amorphous crystalline granite, some of which may even be thrust as veins into the less highly changed parts above and around.

Objections on various grounds have been raised to the igneous theory of granite. It is a well attested fact that quartz is sometimes found containing water—not water of crystallization, as it is chemically combined with many substances, but in a fluid form imprisoned in microscopic cells. In some cases this has been observed to such an extent that the transparency of the quartz is interfered with, and it assumes a milky appearance, caused by the refraction of the rays of light, in the same way that snow is white. These cells, however, are so minute that a section of the quartz has to be made and viewed with a microscope. Sorby and later observers have shown that these cavities amount to a thousand millions to the cubic inch. It has been further stated that the water forms 5 per cent. of the whole bulk. The contention is that a degree of heat far less than is required to reduce silica to a molten or pasty condition favourable to its crystallization must be sufficient to drive off all water. But the question is, if the rock is under such enormous pressure, where can it be driven to?

It is not only difficult, but utterly impossible, for us to determine what may take place in Nature's laboratories, or even to explain admitted facts. But in answer to this objection it may be said that Forbes has asserted that specimens of

lava taken from Etna whilst still flowing contain crystals of stilbite, which is a mineral containing 16 per cent. of water. Mr. Sorby has also shown that quartz of undoubtedly volcanic origin contains cavities holding a fluid. Now it appears to me that instead of these facts being presented as an argument to disprove the plutonic origin of granite they should rather be expected as a normal condition of plutonic and volcanic rocks. It is generally admitted that the explosive force in volcanic motions is steam. Just as carbonic gas permeates and renders bread porous, so lava is rendered porous by the action of an elastic fluid whilst it is in a plastic condition, the result being float stone and pumice. Now provided the mass is in a given viscid condition, under a degree of pressure which counterbalances the expansive force of the imprisoned steam, then as the temperature lowers and the mass becomes solid so will the vapours condense and finally assume a liquid form. Pressure, therefore, must be reckoned with as an important factor.

Mr. Sorby has, indeed, ingeniously estimated the probable pressure under which granite consolidates by the ratio between the cavity and the contained bubble. Assuming the temperature of consolidation to have been 680°, or a dull red heat, he infers that in many cases the pressure under which granite consolidates must have been equal to that of an overlaying mass of rocks fifty thousand feet thick, or more than nine miles. The natural inference is, that a perfectly anhydrous fusion, or the reduction of a rock to the state of a completely homogenous glass, should be comparatively rare.

Another objection has been raised on the specific gravity of quartz. It has been shown that whilst the specific gravity of quartz is about 2·6, that of fused silica is only 2·2. But here, again, the fact of pressure must be considered, and the probabilities are greatly in favour of an alteration of the specific gravity. The substance would naturally be more dense. But apart from this, the late Mr. Forbes pointed out

that the siliceous tests or shells of certain infusoria are as low as 2·2. So the force of the argument based on specific gravity is materially weakened, if not entirely removed.

It has been further objected that granite rocks contain minerals of a basic character which could not have existed in a state of fusion with free silica without combining with it. But it will be admitted that it is exceedingly dangerous for us to affirm what can or what cannot be accomplished in Nature's laboratories, planned on the immense scale on which she works and under conditions which we cannot parallel, as the two factors—temperature and pressure—are indefinitely greater than we can command.

But a direct answer to the objection may be given in the fact that in the Vesuvian lava, leucite—a most intractable mineral—may be seen to have enclosed crystals of augite, which is easily fusible.

As far back as 1846 Scheerer showed that there existed in granite various minerals which could not have consolidated save at a comparatively low temperature. He instances gadolite, orthite and allanite, which cannot endure a higher temperature than a dull red heat without altering their physical character; and he concludes that granite, though it may have possessed a high temperature, cannot have solidified from simple igneous fusion. We may conclude, therefore, that the manner in which rocks have been melted within the earth's crust is not the mere simple fusion which we can accomplish artificially, but that it has involved conditions which have not been successfully imitated in any laboratory or furnace.

Although, as we have said, a typical granite is composed of felspar, quartz and mica, yet it will be readily admitted that by a replacement of one or more of those constituents, or additions thereto, a rock may be considered a granite and yet differ largely from our type. Imagine the stuff or material

of which granite is composed blown into a bubble by gas or steam: we shall have what the Cornish miners call a 'vugg.' Under these conditions, as the pressure is removed the various substances will crystallise out into more definite and perfect forms.

I am able to place before you a fairly good specimen of such a cavity. The orthoclase has some of its faces well developed. You will perceive also that many of the crystals of quartz have their pyramids very perfect. But I would especially draw your attention to the beautiful hexagonal tabular crystals of muscovite or potash mica. In addition to these typical constituents we have a further substance—tourmaline. In many granites this is found in a more or less amorphous condition. In the specimen before you there are several good hexagonal prisms. In some cases the ordinary black tourmaline has suddenly changed into the peridot, or honey yellow tourmaline. Good sized peridots have evidently been broken off, as the juncture of their bases are remaining.

Tourmaline is exceedingly variable in its composition, but all varieties contain silicate of alumina, boracic acid, iron, magnesia, soda, lime in varying proportions, and sometimes lithia, phosphoric acid, and florine.

Felspar, which enters so largely into and gives character to granite, is generally of two kinds—orthoclase or potash, and oligoclase or soda-lime. Sometimes, however, there is simply a soda felspar, or albite. Orthoclase is the most common constituent. When the crystals are allowed freely to develop they are generally simple monoclinic, but sometimes twined. In the porphyretic granite of Cornwall and Devon the crystals develop several inches in length, and the twining is shown on the fractured crystal in a longitudinal line dividing into two halves. Sometimes these twins are hemitropes or macles, in which one-half of the crystal along the dividing line is turned round, and is thus known as the Carlsbad type.

Orthoclase is presented to us under many conditions, and thus yields numerous varieties. To a large extent the colour of granite depends on its felspar: hence we have it red, pink, grey, greenish, blackish. Sometimes it is translucent, and gives a pearly surface when cut and polished. It is then known as adularia. Minute scales of mica are sometimes enclosed; it is then known as sunstone. At other times small crystals of specular or titanic iron, when it is called aventurine. Coloured with a copper salt it is amazon stone. Orthoclase is very liable to decompose. The carbonic acid in the atmosphere, rain, and spring water, acts on the potash and dissolves it, leaving a more pure clay; this is known as kaolin or china clay, and is extensively used in the manufacture of porcelain. The purifying and exporting of this material forms an important branch of trado in some parts of Cornwall.

Quartz is the next important mineral in our typical granite. This is, as a rule, found in irregular angular grains, though occasionally in double hexagonal pyramids. Colourless quartz is the most common; but there are exceptions to this rule, as it is sometimes grey, brown, or blueish.

Usually the least abundant mineral in granite is mica, yet it is often in sufficient quantity to give a pronounced colour to the rock. Muscovite—or potash mica—like other varieties, is found in thin scales of an irregular form, or in sixsiden plates. It is highly double refractive. By a simple polariscope which I have constructed I am able to exhibit a plate in a polarized condition, and which shows this characteristic feature. Along with muscovite, biolite –or magnesium mica—sometimes occurs.

In some Cornish granite Lepidolite, a litha mica, is found. It varies in colour, and is found rose colour, lilac, violet grey or white.

A black mica—Lipidolemane, an iron potash mica—is sometimes found in the same rock. Professor Heddle has found that the black mica in Scottish granite is of a different species, and has named it Haughtonite.

Distinct from the typical granite we have now considered, there are many other rocks which differ in some material points from it, yet are still granites; and again, others which, if not true granite, are so closely related to them that no treatment of the subject could be considered complete unless they were mentioned. These varieties depend mainly on three factors—namely, accessions, substitutions and eliminations. In the first place, other minerals are added: Zirkel mentions no fewer than forty-four distinct minerals which give character to granite. As we have seen, tourmaline or schorl is often present, when it is known as schorlaceous granite. Sometimes tin makes its appearance, when it is called stamiferous; or epidote may be found. Garnets sometimes occur; hornblend, too, which constitutes the syenite of Pliny. This is a hornblend granite, but not the syenite of modern petrologists.

Now it may be an interesting question to ask how these diverse minerals are sometimes found in our typical granite. It is difficult, perhaps impossible, to give a satisfactory answer, but I would offer a suggestion :—

We know that in some cases granite has been forced up from below—either by its fluidity or the tremendous pressure behind it, or both, it has been forced into the natural fissures of the strata through which it has passed; sometimes entering mere cracks, until its ramifications have become hair-like. But where great masses have been injected under great pressure and intense heat the strata through which it has been forced have in some cases been decomposed—for instance, coal has been reduced to graphite, as in one coalfield in Ayrshire. But provided the chemical composition of the altered rock is the same as that of the granite, and is raised to a molten condition by the intrusion. Professor Geikie says: "It is not necessary that when crystallised it should be different in any noteworthy degree from the ordinary or intrusive granite." He further says: "In regions of intense

metamorphism the foliation of the schist may be observed to become here and there somewhat indefinite, until it disappears altogether, and the rock assumes a thoroughly granitic character. Between gneiss and granite there is no difference in mineralogical composition—in the one rock the minerals are arranged in folia, in the other they have no definite arrangement. Gneiss might be called foliated granite, and granite non-foliated gneiss. The two rocks may be observed to graduate into each other. In Aberdeenshire, for example, the common grey mica schist and gneiss may be seen to pass insensibly into the ordinary grey granite. In such cases it has been naturally concluded that granite is the ultimate stage of metamorphism." Now, accepting this state ment of Professor Geikie's, we can readily understand that under these circumstances new chemical combinations will take place, with the result that new minerals will be found. It is in this metamorphic granite that such minerals as garnets, &c., are sometimes found.—Rutley and Butler, in *Ency. Brit.*

But the character of granite is further affected by what I call substitution. For example: when one of the constituents of our typical granite gives place to a different mineral. In Luxullian, Cornwall, there is a rock found in large boulders composed of quartz and orthoclase of a fine flesh colour and in large crystals, but mica gives place to tourmaline or schorl. It is certainly a variety of granite, and has been named luxullianite by Pisani. As far as I am aware, it has only been found as detached boulders. The specimen I have has been procured direct from Luxullian. When polished it is very beautiful, as the contrast between the brown or blue schorl and the flesh colour orthoclase is exceedingly striking. The sarcophagus of the Duke of Wellington in St. Paul's Cathedral is wrought out of a splendid block of this granite.

A third change is produced by elimination, in which case some constituent of the typical kind is left out, with or without any replacement or substitution. As an illustration,

I would take syenite as understood by modern petrologists, in which hornblend takes the place of quartz and mica altogether disappears. Again, we have aplite or semi-granite, which is felspar and quartz without mica. When the felspar disappears and only quartz and mica are the constituents we have what is known as griesen. This is often a tin-bearing granite. An intimate mixture of orthoclase and quartz in fine grains is known as felstone.

In Cornwall there is a quartz porphyry known as elvan, in which rounded grains of quartz are disseminated through a felsitic base. Also in many of the West of England granites, as well as some of those in Westmoreland, large crystals of orthoclase are imbedded in a fine grained base, producing a porphyritic granite.

Structural arrangement, apart from mineralogical character, often produces varieties. When the individual constituents are developed on a large scale we have what is known as giant granite. Or when crystals of orthoclase are associated with quartz in a peculiar parallel arrangement. Thus we have what is known as graphic granite, or Lapis Judaicus, the disposition and arrangement of the crystals in a given direction resembling Hebrew characters.

But here I will close. I am aware I have in no sense exhausted the subject, neither have I done it justice; but if I have said that which will lead to such a discussion as shall correct my blunders and increase my information I shall have achieved at least one desirable point.

ORDINARY MEETING,

Held in the Free Library on Monday, July 2nd, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

A Paper was read on "Portland and Kindred Stones" by Mr. J. Wilding.

A Field Meeting was held at Burton on Saturday, July 7th, 1894, conducted by the President.

The well-known section at Burton Point where pebble beds are seen resting upon the lower soft bunter was inspected, and notes made of the atmospheric erosion of the rocks there. Fresh sections exposed in the railway cutting were also visited. On the west side of the cutting a slickensided face of a North and South fault was found to be striated horizontally. The large size of the pebbles in the pebble bed also arrested attention; one pebble of quartzite was extracted which measured 7¼ inches in length.

A Field Meeting was held at Cefn Caves, near St. Asaph, on Monday, August 6th, 1894, conducted by the Secretary.

The entrance to the cave—or rather, fissure—is found on the side of a hill overlooking the valley. On entering, it was seen that the bed of the cave had been thoroughly turned over and examined by previous visitors. Along one fissure the work had apparently been fruitless, as the point at which the digging had been discontinued was clearly visible. Along another fissure the work had been more successful, and some of our members brought away small portions of cave breccia containing fragments of bones—too small, however, for recognition. On leaving the cave the party was invited by Mrs. William Wynn to inspect the remains which have been exhumed and are kept in safe custody at the Hall. These have been described by Professor Boyd Dawkins and Professor T. McKenny Hughes.

ORDINARY MEETING,

Held at the Free Library on Monday, September 3rd, 1894, the President (Mr. D. Clague, F.G.S.) in the Chair.

Exhibits.—Specimens of salt brine and of the first salt manufactured in the Isle of Man were exhibited by Mr. T. W. Craine. Landscape marble, exhibited by Mr. H. T. White in illustration of his paper.

Auditors.—Messrs. W. Owen and H. T. White were elected Auditors under Rule V.

A Paper was read on

LANDSCAPE MARBLE,

By Mr. H. T. White.

[Abstract.]

At our September meeting of last year I exhibited several slabs of Cotham, or Landscape Marble. I mentioned that scanty information only was obtainable as to the cause of the arborescent markings, but that the general opinion was that they were due to the infiltration of oxide of manganese. Having stated that after careful examination I had failed to obtain the reactions due to manganese, the President suggested that if the markings were not due to this mineral then carbonaceous matter was the probable cause. The Journal of the London Geological Society for 1891 contains a full and interesting account, by Mr. Edward Wilson, curator of the Bristol Museum, of the Rhætic rocks near Bristol, showing the local position which the Cotham Marble occupies in that series. This was followed by a paper by Mr. H. B. Woodward, of London, on "The Formation of Landscape Marble." This paper did not, however, universally commend itself to geologists as a satisfactory solution of the difficulties of the case, but it stimulated thought and led to careful research. In particular, the matter was taken up by Mr. Beeby Thompson, of Nottingham, and the result of his investigations—fuller than by any before him—was published in the August number of the London Geological Journal. The following is, in great part, a summary of what Mr. Thompson has said and done:—

Landscape Marble is a hard, close grained, argillaceous limestone, with a conchoidal fracture. As a whole it takes a moderate polish, but the darker portions polish best. It is fairly continuous over a considerable area in the neighbourhood of Bristol as a plain banded limestone. In places, isolated masses are found having a crinkled upper surface, and it is in these that the characteristic internal markings are found. These detached masses vary from a few inches to three or four feet in length, and in extreme cases have a depth of eight or nine inches. In some specimens there is a clear margin at each end, beyond the markings; in others the markings are broken across at one or both ends. The stone practically consists of three portions—the upper and the lower being striated; the middle portion, in which the markings occur, is whiter than the upper or lower portion. It is the lower dark band which is so interesting, because from this the arborescent markings have been derived. The crinklings of the upper surface follow the general form of the tops of the trees—seem, in fact, to be a kind of roofing supported by them.

Mr. Thompson says that the markings and striæ in the piece figured (1) in his published paper are composed of aragonite, while in the piece he has figured (2) they are calcite. If this be so, it raises an interesting question as to whether the cause of aragonite, as generally stated, is correct, or whether other circumstances than heat have to do with $Ca. CO._3$ taking the form known as aragonite. Chemically, the mass is practically carbonate of lime, with layers containing more or less of clayey matter. After dissolving away the carbonate of lime the residue shows traces of iron, aluminium, manganese, magnesium, a little phosphoric acid, and a few grains of quartz. Mr. Thompson then says that "without doubt *carbon* is associated with the darker markings; in fact, it is to carbon that the colour is due." In proof of this statement he mentions that a white spot may be produced in a few seconds by directing a jet of flame from a blow pipe on the darker portions.

Mr. Thompson then deals at length with the cause of the markings, as deduced from his researches. He says: "I commenced my investigations of Landscape Marble with the preconceived idea that its peculiar characteristics were due to interbedded layers of vegetable matter, which continued to decompose and evolve gases after its deposition; and that where a layer of extra thickness occurred the decomposition continued, whilst a thickness of several inches of new sediment was laid down, with the result that arborescent markings were produced along the lines taken by the escaping bubbles." A careful examination of all the characteristics of the stone, and some experiments aiming at its artificial reproduction, have confirmed him in his main idea. He further says: "The rock was without doubt a sedimentary one, although at times it seems concretionary. It has undergone considerable change, both physical and chemical, since its deposition." "That the arborescent markings originated from the dark layer, not the latter from the former, admits of no doubt, for all the markings start from the dark layer, whereas they finish anywhere, some at only half the height of others; the narrowest portions are downward, whereas the opposite would have been the case if the source had been above. But the most conclusive reason of all is the invariable lifting of the matrix contiguous to the dark markings." "The material of the dark bands must have been more plastic or less dense than the matrix to have allowed itself to be squeezed or lifted from its original bed through overlying layers, for not only was it so lifted through comparatively heavy inorganic material, but when it reached the surface it spread out in all directions and produced exceedingly thin films of dark matter, which completely roofed in the arborescent markings."

Mr. Thompson then adduces reasons for his belief that carbon, and not oxide of manganese, was the darkening matter, and again particularly refers to the readiness with which the blow pipe will bleach a spot in the dark portion.

He also found by experiment that bubbles of carbonic acid gas would lift and disseminate finely divided carbon from a layer covered with fine sand, whereas they would not lift manganese. He then describes a series of laboratory experiments with material similar to that of which the specimens were composed. He has been able not only to produce arborescent markings but also a crinkled upper surface, owing to the lifting power of escaping gases.

It is interesting here to notice that Edward Owen, of Bristol, who in 1754 published the first account of Cotham Marble, seems to have had a clearer insight into the cause of the markings than any other writer during the century following. Of course, to the outer world—that is, to those who are not members of geological societies—it doesn't matter an atom how certain markings on a pretty bit of stone were produced. But our present knowledge of geology has largely been obtained by piecing together observations and deductions which, taken alone, must have seemed of trifling value. These trifles have, however, often proved themselves the germs of truth from which large and important facts have been derived. I feel, therefore, that the thoroughness with which Mr. Thompson has done his work will not only lead to some revisions in our text books, but may also lead to fuller knowledge in other directions.

ANNUAL MEETING,

Held at the Free Library on Monday, October 1st, 1894, the Vice-President (Mr. T. R. Connell) in the Chair.

A Paper was read on

EXTINCT ANIMALS AND THEIR RECENT TYPES,

BY CECIL F. WEBB, D.D.S.

The problem to which I desire to draw your attention is that of the extinction of species. In studying the subject it

will be desirable to glance through some of the main orders of animals, and note the laws which govern their appearance and disappearance.

The *Marsupials* come first. In this order no placenta is developed; the female transfers the embryo in a very immature condition to an external pouch. It has been said that these made their first appearance in Europe, and died out in the Miocene period, before the higher placental forms; though they disappeared thus in Europe, they still survive in Australia. Before their disappearance in Europe they flourished and developed in all possible ways, becoming some carnivorous and some herbiverous, insect eaters and root eaters; some lived in trees, some burrowed in the soil, while others flew like bats. Some, such as Diprotodon, stood more than sixteen feet in height, with a skull more than a yard in length; Thylacaleo, called by Owen the "marsupial lion," rivalled it in size. Corresponding with these are the fossil wombats—the Nototherium, for instance, far exceeding the living species in size. This creature had a most hideous skull, nearly as broad as it was long; evidently, therefore, the living marsupials of Australia, the largest of which only reach five to six feet in height, are but diminished and scattered survivals of the past.

We next turn to the *Proboscidians.* Of these the only living representatives are the elephants. No animal seemed more fitted to survive in the struggle for existence, being of gigantic size, possessing a skin which made them invulnerable, their large compressed molars serving them through the longest life. Their food consisted of branches and foliage of trees, which was not likely to fail them; yet we have only two species surviving to the present day out of a large number of fossil forms! The glacial period is held to be responsible for the extinction of the mammoth, but what killed the mastodon and Deinotherium? This species of elephant, besides other proboscidians, appeared in the Miocene

period of India alone, with no climatic conditions to interfere with their continuance, and a number of species ranged over Britain, Europe, Asia, and North America. One is tempted to think their unwieldy size might have been adverse to their continuance, but then we are confronted with the tiny elephant of Busk—Elephas Falconeri--whose height did not exceed from 2½ to 3 feet; yet it perished also, leaving only the Asiatic and African elephants to represent the large number of proboscidians that formerly flourished.

We next consider the *Ungulates*. The history of the genus Camelidæ is an interesting one; the earliest appearance of it seems to have been the Miocene Probrotherium, in which the bones of the feet had not coalesced, and the mouth had a complete set of incisor teeth. The Protolabus also had a full set of incisors, but they fell out readily. The Procamelus had incisors like the present camel, the bones of its feet were coalesced and became "cannon-bone." Pliauchenia and Auchenia led up to our present Llamas; a very continuous decay in the teeth is observed from their readily falling out, failing to cut the gum, to their complete disappearance in some of the species, a process which is repeated in other cases also.

The genus Equus has had a long history of slow development. In the lower Eocene of New Mexico are found the remains of Eohippus, an animal about the size of a fox, with a full complement of teeth (44) and a rudimentary thumb, besides four toes on its fore feet; the hind feet had three toes, all the digits terminating in hoofs. The Orohippus is found in beds higher than the last. This also had four toes on the fore feet and three on the hind feet, but the third digit is the largest and the rudimentary thumb was wanting. It had the same number of teeth (44), but an interval separated the pre-molars from the canines—a peculiarity which characterises the modern horse.

In the Miocene and Pliocene times the Hipparion made its appearance. The anatomical differences between it and its predecessors were not very great; the central digit was the only one which touched the ground; the second and fourth, though visibly furnished with small hoofs, were much reduced in size, and had no part in supporting the weight of the animal. Finally the true horse appears, in which the useless second and fourth digits are reduced to *splint* bones concealed beneath the skin. We can also follow the specialization of the teeth, though this, strange to say, has not kept pace with the modifications of the toes. Our modern horse still possesses forty-six teeth, but the first pre-molar, which was a good "working tooth" in the Eocene and Miocene species, is in the horse rudimentary, functionless, and early lost; the canines have greatly diminished in size, and are rarely to be seen in the female. So, practically, a large number of full-grown horses have eight teeth fewer than their predecessors. In this respect the horse forms an exception amongst the land mammalia, probably showing that it has now reached the highest point of which the species is capable.

The Perissodactyls, odd-toed animals, survive in a more fragmentary form than perhaps all other sub-orders of Mammals. There are in this group seven principal families, of which only three survive. Of the genus Tapiridæ, one family—the tapir—alone survives. The rhinoceros is a survival from some of the most ancient of mammals of the Eocene period; the highest form *(R. Tichorhinus)* was contemporary with early man, and soon died out. The extinct families of the Perissodactyls were clumsy animals of low specialization and undeveloped brain.

Amongst the pair-hoofed Ungulates—Artiodactyls—we have a curious instance in the hippopotamus of the primary type, from the Eocene, with tuberculate teeth; and from being an animal that liked marshy ground it has become almost an aquatic creature, and has accordingly preserved

the completeness of hand and foot. The four toes are fully developed, the breadth and height of the muzzle are produced by the enormous development of the middle incisors and canines, all of which are furnished with roots that are not closed but open wide apart. The typical ruminants are highly specialized both in limbs and dentition; there are no incisor teeth in the upper jaw, their place being taken by a hardened pad of gum. The only teeth in the upper jaw are six molars on each side; in the front of the lower jaw is a row of eight teeth, then a vacant space followed by six grinders. The typical dental formula of the ruminant, then, is this:—

Incisors $\frac{0-0}{3-3}$ Canines $\frac{0-0}{1-1}$ Pre-Molars $\frac{3-3}{3-3}$ Molars $\frac{3-3}{3-3} = 32.$

The true ruminants appear in the post-Pliocene deposits, when the stags attained their largest size and greatest abundance. The Irish elk was most remarkable for its size and the dimensions of its antlers, which sometimes spread as much as ten feet from tip to tip, much exceeding any now living.

We will next see how the *Carnivora* have fared in the struggle for life. The cats are the most powerful and highly specialized of the carnivores; the teeth are reduced to 30, the canines are greatly developed, all the pre-molars and molars except the last molar in the upper jaw are trenchant; its claws are withdrawn when not in use, and are always kept sharp. The most highly specialized of this group was the terrible sabre-toothed Machairodus, whose remains are found in Britain, Europe, India and America. It appears in the Miocene and disappears in the post-Pliocene. Its teeth were reduced to 26, the canines were much enlarged, trenchant, and sabre-shaped. The cat and tiger of to-day are feeble representatives of this, their powerful ancestor.

In the instances which I have mentioned, and many others which could have been named if time permitted, I have endeavoured to show how *lowly* forms of living creatures lived

on through every possible vicissitude, and other forms have disappeared with astonishing rapidity, whole orders having become extinct. Some highly specialized forms live on and head the animal kingdom to the present day; others have developed to a high point of specialization, only to die out as rapidly.

Much in this subject is at present quite inexplicable, but it is to be hoped that a simple statement of the facts of various cases of extinction and of permanency may help to bring nearer the time when the problem will be more completely solved.

The Annual Report was submitted by the Council, also reports of the various Committees and the Treasurer's Financial Statement, all of which were adopted and ordered to be printed.

The Officers and Council for the year 1894-5 were then elected as follows :—

President :

MR. T. R. CONNELL.

Vice-President :

MR. D. CLAGUE, F.G.S.

Treasurer :

MR. J. PATERSON.

Secretary :

MR. W. SCOTT-WALKER.

Council :

MR. G. A. HOWARTH. MR. H. T. WHITE.
MR. J. H. JONES. MR. W. B. BARR.
MISS S. GLUCK.

ANNUAL REPORT, 1893-4.

On retiring from office your Council beg to present the following Report:—

Since the last Annual Meeting we have lost one member by death—viz., Mr. W. H. Miles, a useful and active member, whose loss we much deplore—and five by resignation, so that the roll of membership at present stands at 7 honorary and 64 ordinary members, against 7 honorary and 70 ordinary members last year, being a decrease of 6.

Eleven Ordinary Meetings have been held, at which the following Papers were read:—

"The Empire of Reptiles," by Mr. D. Clague, F.G.S.

"The So-called Forest Beds of Leasowe," by Mr. Charles Potter.

"The Beginning of Physical Life," by Mr. C. F. Webb, D.D.S.

"Coal Mining," an Address by Mr. G. A. Howarth.

Illustrations of Geological Sections, &c., with lantern, by Mr. W. H. Read.

"Granite: its Pedigree and Relations," by Rev. O. Beckerlegge.

"Notes on the Storeton Series of Footprints," by Mr. Osmund W. Jeffs.

"Portland and Kindred Stones," by Mr. J. Wilding.

"Landscape Marble," by Mr. H. T. White.

"Extinct Animals and their Modern Types," by Mr. C. F. Webb, D.D.S.

At the first meeting in the year 1894 no paper or address was delivered, but the whole evening was spent in the inspection and discussion of a large series of minerals, fossils, photographs, &c., lent by members and friends. The meeting was one of considerable interest and instruction.

The Field Meetings held during the year have been as follow:—Saturday, March 3rd, Poulton Railway Cutting; Easter Monday, Llangollen; Whit Monday, Ingleton; Saturday, July 7th, Burton; August Bank Holiday, Cefn. In addition to these, one visit was made on Saturday, Dec. 9th, to Liverpool Museum to inspect the collection of minerals bequeathed by the late Right Hon. Lord Derby.

The Committees appointed in the earlier part of the Session have been quietly and steadily working during the year. Their various reports are appended.

It only remains for us to say that the Association has done good, steady work in the past, is continuing that work, and we hope the members will be ready and united to carry it on in the future still more vigorously than heretofore.

Report of Committee for Naming Minerals from Australia.

The work of examining strange minerals without any hint as to their character is necessarily a slow one, as each mineral has to be separately tested in a variety of ways; and if this work has to be done by persons already occupied with other work the members of the Association will bear with them if they do not report on all the specimens at once.

Fifteen specimens have been tested, named and labelled; so far they are mostly lead and copper ores. The list is as follows:—*Lead:* Galena, 2 specimens; Cerrusite, 2 specimens; Anglesite. *Copper:* Pyrites, Cuprite, Tenorite and Azurite. Also Pyrolusite, Asbestos, Quartzite (no gold found), Quartz (with gold), Quartzite (with gold), Limestone.

Report of Committee on Microscopic Petrology.

The members of the Committee have held themselves in readiness at all times to assist members in microscopic work, but their services have not been required during the year. Their attention has, however, been drawn to the question of

the organic or purely mineral character of Eozoon, and having obtained a few slides of stones supposed to contain Eozoon, they subjected them to microscopic examination.

The first was a stone from Twt Hill, of a pale greenish white colour, with well-marked banding said to be Eozoonal. A section ground by Mr. A. Pritchard showed, under the microscope, clear indications of being a chlorite schist; a few markings bore a distant resemblance to portions of canal structure, but in the absence of any more features its organic origin must be denied.

The next slide was one purchased from Mr. Hensolds, of London, cut from a stone from Led Beg, Sutherland, Scotland, said also to be Eozoon. This is certainly unlike any of the sections of Eozoon as published by Sir J. Dawson. Some portions of it appear to have a cellular structure, and while not prepared to deny its organic character, certainly it is not Eozoon Canadem.

A slide of Eozoon purchased at a Liverpool shop (Thompson, Lord Street) is largely crystalline in structure, but in places there are markings which appear to be tubuli, and a canal system similar to those figured by Sir J. Dawson. Hence we conclude it to be Eozoon, though a poor specimen.

Two other slides also engaged our attention—one cut from a boulder from the Boulder clay, Bootle, by Mr. Pritchard, proves to be ophitic in structure, crystals of augite and olivine being distinctly formed amid irregular patches of Biotlite and basic felspar, and in places the doubly twinned felspar are broken and crossed by undetermined minerals of a later growth—olivine basalt. The other slide, cut by Mr. Pritchard from a limestone taken by Mr. Clague from some ballast heaps on Kensington Fields, proves to be a limestone of very fine texture, with distinct polarization, the structure being so fine it is impossible to say whether the limestone is dolomitic. We suspect it to be so, however, on account of the polarization colours being somewhat faint.

Report of Publication Committee.

On entering upon our work we had first to complete the Journal of the preceding year, which was done as quickly as possible and distributed to the members. The spare copies were bound, and copies sent to Societies with whom we have exchanges.

The only work done since has been the printing of a list of Officers, Committees and Members, being part 1 of Vol. 14. We then received instructions from the Council not to print any more, as the subscriptions were coming in so slowly that we were not warranted in incurring any more expense. This is to be regretted, as injury is done to the Association by the non-issue of our Journal.

It is to be hoped that all members will pay their subscriptions at the commencement of the Session, according to Rule, and that all owing arrears will take the matter to heart and note that through their remisness the Association suffers.

Report of Library Committee.

The Library during the past year has kept up to its usual standard, and has proved a source of great value to the members of the Association.

It has again been enriched by donations from various sources, amongst which may be named the British Museum N.H.D., the Governments of New South Wales and Victoria, United States Geological Survey, Professor T. McKenny Hughes, F.G.S., and T. Mellard Read, F.G.S., to whom, with others, the thanks of the Association are due.

In the course of the year the number of members using the Library has been 25; books taken out, 30.

The number of volumes ready for binding has increased during the year, but the Committee regret that the appeal to the members for subscriptions has not led to such results as would justify them incurring the cost of binding. They hope that during the ensuing year they may be enabled to do so.

The bound books available for reference number 121.

(For the Committee), Thos. R. Connell.

LIVERPOOL GEOLOGICAL ASSOCIATION, in Account with the Treasurer.

For the Year ending 29th September, 1894.

DR. **Disbursements.**	£	s.	d.
To Printing and Stationery	12	2	8
,, Postages and Incidentals	3	15	5
,, Rent of Room	2	5	0
,, Gratuity to Attendant	0	10	0
Balance in hands of Treasurer	0	10	1
	£19	3	2

Receipts. *CR.*	£	s.	d.
By Balance from last year	6	2	3
,, Subscriptions, viz. :—			
1 for year 1891-92			
6 ,, 1892-93			
35 ,, 1893-94			
2 ,, 1894-95			
1 ,, 1895-96			
45 Subscriptions at 5s.	11	5	0
,, Receipts from Authors for Printing	0	18	9
,, Donations to Binding Fund	0	14	8
,, Sale of Transactions	0	2	6
	£19	3	2
By Balance	£0	10	1

October 1, 1894.—Audited and found correct,

(Signed) HENRY T. WHITE, WILLIAM OWEN, } Auditors.

FIG. 1.—Slab of Keuper Sandstone, showing footprints of *Cheirotherium Stortonense*. *(Storeton*

[O.W.J.—No.

FIG 2.—Sandstone, with footprint (probably of a Chelonian). (Storeton.)

FIG. 3.—Footprint of Rhyncosaurus. *(Storeton.)*

O.W.J.—No. 124.

FIG. 4.—Footprint of Rhyncosaurus, with impressions of claws superposed on original footprint. (Storeton.)

O.W.J.—No. 125.

FIG. 5.—Footprint of a small Saurian, with distinct claws on toes. *(Storeton)*
[O.W.J.—No. 127.

FIG. 6.—Tracks of the same animal, superposed on ripple marks. (Storeton.)
[O.W.J.—No. 128.